

sion chamber 3 between apertures 2 and 5. It is then possible to vent the expansion chamber 3 and region 14 to atmospheric pressure whilst maintaining high vacuum in region 15. This facilitates access to the components most prone to contamination, so that they can be readily replaced or refurbished.

The ions that have passed through aperture 11 are directed by an ion lens 16 into an ion optical device 17. Device 17 assists in containing the ion beam, which otherwise would tend to diverge rapidly under the influence of positive ion space-charge, and cause severe loss of sensitivity. The directed flow of neutral gas from the plasma, however, is not confined by the ion optical device 17 and diverges from the ion beam to be removed, along with the general back pressure of gas in the chamber 6, by the vacuum pump 7. Device 17 may be a quadrupole, a higher order multipole, an ion guide or an ion lens. As mentioned above, it is advantageous if the transmission-enhancing device can be made to the mass-selective. Preferably it will be a quadrupole, although in principle another mass selective device, such as a magnetic sector, could also be employed.

Ions transmitted by device 17 are focussed by the ion lens 18, and pass through an aperture 19 into the second evacuated chamber 20, maintained at a pressure lower than that of the first evacuated chamber 6 by a high-vacuum pump, preferably a turbo-molecular pump, located at 21. The pressure of this chamber is of the order 10^{-3} to 10^{-5} mbar, typically $1-2 \times 10^{-4}$ mbar. Aperture 19 has a relatively small diameter, typically 2-3 mm, thus establishing a pressure differential between the first evacuated chamber 6 and the second evacuated chamber 20. This prevents the background gas from chamber 6 from entering chamber 20, reducing the gas load on chamber 20, and so minimises any residual pressure in the chamber 20 due to the neutral gas load from the plasma. It is advantageous if aperture 19 is mounted on an insulator 22, so that it can be biased negative, causing ions to pass through it with relatively high translational energy. This helps to ensure efficient transport of the ions through the apertures 19 both by lowering the charge density within the beam and by minimising the beam divergence.

The ions are focussed by ion lens 23 into a collision cell 24, which is located in the second evacuated chamber 20. The collision cell 24 has an entrance aperture 27 and an exit aperture 28. As the ion beam emerges from the aperture 19, the neutral gas flow diverges and is skimmed off by the entrance aperture 27 of the collision cell 24, thus further reducing the gas load on the collision cell 24. Located in collision cell 24 is a multipole ion optical assembly 25. This may be a quadrupole, hexapole or octapole. The collision cell 25 is pressurised with a target gas 26, chosen for its capacity to remove, via a mechanism such as attachment or fragmentation, unwanted molecular ions from the ion beam whilst influencing other ions minimally. Typically the target gas may be helium or hydrogen, although many other gases may prove beneficial for specific analytical requirements.

Apertures 27 and 28 limit the gas conductance out of the collision cell, thus allowing it to operate at a relatively high pressure, typically in the range 0.001 mbar to 0.1 mbar, whilst minimising the gas load on chamber 20 and its associated high vacuum pump 21. The transport efficiency of ions through apertures 27 and 28 is improved by biasing the apertures negative. They are mounted on the collision cell by means of insulating gas-tight supports 29 and 30.

Ions that leave the collision cell 24 are accelerated and focussed by ion lens 31 through an aperture 32. This aperture establishes a pressure differential between chamber 20 and the third evacuated chamber 33 thus reducing the gas load on chamber 33, and further minimising any residual pressure

therein due to the neutral gas load from the plasma. It is advantageous to mount aperture 32 on an insulating support 34. The aperture 32 can be then biased negative with respect to ground, typically to -100 volts, so that ions pass through it with relatively high translational energy. This helps to ensure efficient transport of the ions through aperture 32 both by lowering the charge density within the beam and by minimising the beam divergence.

The ions pass through aperture 32 at relatively high translational energy, and pass through a double deflector 35 preferably at the same or highly energy. This deflects the ion beam away from the original instrument axis 9 and along the axis 36 of the quadrupole mass filter 37, which is used to mass analyse the ion beam. The double deflector 35 is advantageously in the form of two small cylindrical electrostatic sectors, cross-coupled and in series. We have found this configuration to be especially effective in reducing to below 1 CPS the unresolved baseline noise signal that is generally present in ICPMS instruments.

Ions of the selected m/e or range m/e are transmitted to a detector, which is typically an electron multiplier 38. The first dynode of the electron multiplier 38 is offset from axis 36 of the quadrupole mass filter, which further helps to minimise the unresolved baseline noise signal. Both the mass filter 37 and the detector 38 are housed in the third evacuated chamber 33, which is maintained at a pressure lower than that of the second evacuated chamber 20 by a high-vacuum pump 39. The pressure of this chamber is less than 10^{-4} mbar, typically about 10^{-6} mbar, although certain types of ion detectors can operate at pressures as high as $2-5 \times 10^{-5}$ mbar.

What is claimed is:

1. A mass spectrometer comprising:
 - means (1) for generating ions from a sample introduced into a plasma;
 - a sampling aperture (2) for transmitting some of the ions into an evacuated expansion chamber (3) along a first axis (9) to form an ion beam;
 - a second aperture (5) for transmitting some of the ion beam into a first evacuated chamber (6);
 - a first pump (7) for maintaining the first evacuated chamber (6) at high vacuum;
 - a first ion optical device (17) located in the first evacuated chamber (6) for containing the ion beam wherein the first ion optical device (17) is a mass selective device;
 - a third aperture (19) for transmitting the ion beam into a second evacuated chamber (20);
 - a second pump (21) for maintaining the second evacuated chamber (20) at a lower pressure than the first evacuated chamber (6);
 - a collision cell (24) having an entrance aperture (27) and an exit aperture (28) and pressurised with a target gas (26), the collision cell (24) being disposed in the second evacuated chamber (20);
 - a second ion optical device (25) located in the collision cell (24) for containing the ion beam;
 - a fourth aperture (32) for transmitting the ion beam into a third evacuated chamber (33) containing mass-to-charge ratio analyzing means (37) disposed along a second axis (36), wherein the mass-to-charge ratio analyzing means is configured to mass analyze the ion beam to produce a mass spectrum of the ion beam such that both the first ion optical device (17) and the mass-to-charge ratio analyzing means (37) operate at the same mass to charge ratio, so as substantially to minimize the formation in the collision cell of interfering ions having the said mass to charge ratio; and